UNMANNED SPACECRAFT

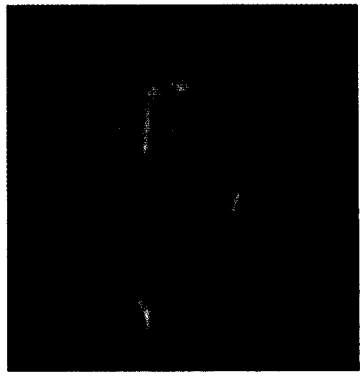
Important Terms

satellite - natural or artificial object in space that orbits the Earth
orbit - the path a satellite takes around a celestial body
apogee - the highest point of an orbit
perigee - the lowest point of an orbit
Sputnik - the first artificial satellite
COMSAT - communications satellites
INTELSAT - International Telecommunications Satellite Organization
NAVSTAR - navigation satellites
LANDSAT - satellites that locate natural resources and monitor conditions on the Earth's surface
GOES - Geostationary Operational Environmental Satellites

SATELLITES

Origin

The word satellite comes from the French language. It was a name for a guard or attendant. In 1611, the German astronomer **Johannes Kepler**, while studying the planets and stars, discovered several objects moving around Jupiter. He named them satellites of Jupiter - the guardians of the giant planet.


Johannes Kepler

In today's world, most of us realize the impact satellites have on our lives. We know that they affect our televisions and our telephones, and even help us in predicting the weather. They are a part of our daily lives. Today, astronomers still use the term satellite for natural objects in space. An example of a natural object in space is the Moon. In fact, the Moon is the Earth's only natural satellite.

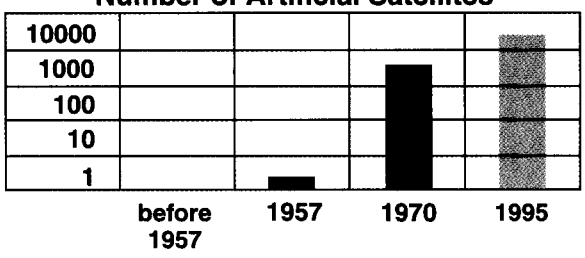
In 1957, the Russians launched ***Sputnik***, the first artificial (manmade) satellite. Since then, astronomers have used the term **satellite** for either a natural or an artificial object in space. We commonly call any object that orbits the Earth a satellite.

Artificial Satellites

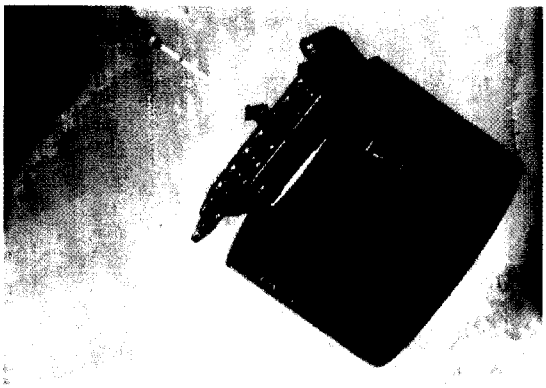
As mentioned earlier, the Earth has only one natural satellite, but as you can tell from this chart, there are thousands of artificial satellites.

In the early days of artificial satellites, the satellites were unmanned. These unmanned satellites are sometimes referred to as unmanned spacecraft. These satellites or spacecraft have many different missions and are placed in categories based on those missions. Some of those categories are communications, navigation, natural resources and weather.

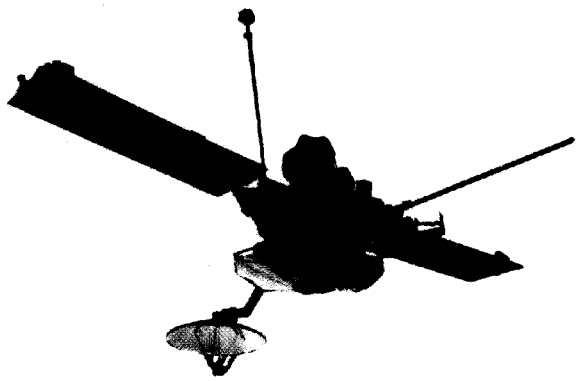
Number of Artificial Satellites



Communication satellites (**COMSATs**) began in 1958 when taped messages were broadcast from orbit on the *Score* satellite. It operated for only 13 days, but our nation was excited. In 1962, *Telstar* 1 became the first commercial satellite. It



Syncom **IV Communications Satellite**

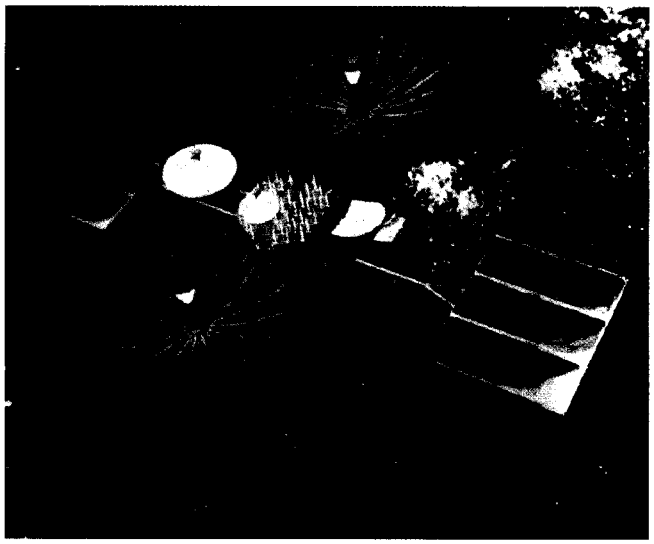


Mariner **10 Mars Observer**

retransmitted as many as 60 two-way telephone conversations at one time. Today, the COMSAT business is huge and growing. National and international corporations are financing the construction, launch and operation of several types of COMSATs, including direct television and video conferencing.

The International Telecommunications Satellite Organization (**INTELSAT**) is made up of 109 nations worldwide that control 16 satellites. In 1989, they launched a satellite that accommodated 15,000 two-way voice circuits and two television channels simultaneously. Another COMSAT is the Tracking and Data Relay Satellite System (**TDRSS**). The TDRSS consists of three active satellites and provides a simultaneous full-time coverage for the space shuttle and up to 25 other NASA low-Earth-orbiting spacecraft. This system relays data and communications between the satellites and Earth.

Telstar I



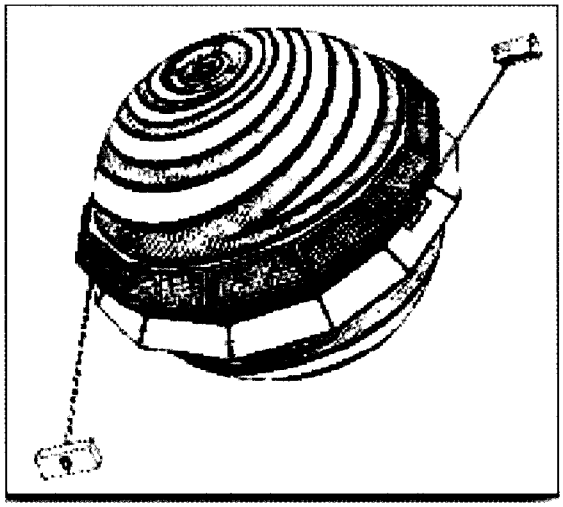
TDRSS (COMSAT)

NASA established a **Deep Space Network (DSN)** which consists of three deep space communication complexes. They provide continuous communications for planetary spacecraft probing into deep space.

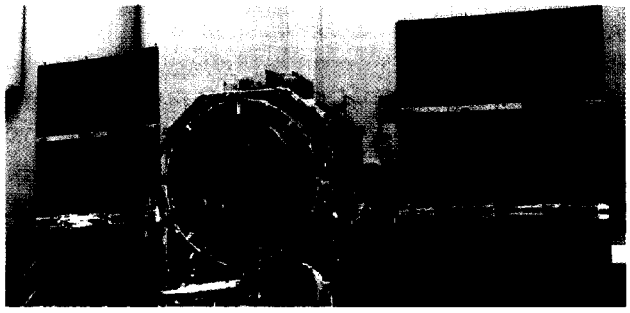
Communication satellites provide reliable and timely communications' information around the world. The communications' payload consists of the electronics and controls that ensure all signals are received, amplified and retransmitted to the appropriate destination error-free. Successful communication links require a direct line of sight with both the transmitting and receiving station on Earth or other satellites. Communication today normally involves an intermediate ground station rather than a direct satellite link.

By the late 1960s, Navigational satellites came into existence. The first navigational satellite, *Transit*, was developed to provide Polaris missile submarines with the ability to fix accurate positions. Another navigational satellite is the **NAVSTAR** Global Positioning System (**GPS**). GPS is a civilian and military navigational satellite that offers a precise positioning service.

Navigation satellites offer a tremendous service with the availability of positioning information 24 hours a day, anywhere on or above the surface of the Earth. A typical satellite navigation system includes a constellation of navigation satellites, the ground control facility to provide accurate positioning information, and the users who possess the proper decoding equipment.



***Transit* Navigational Satellite.**

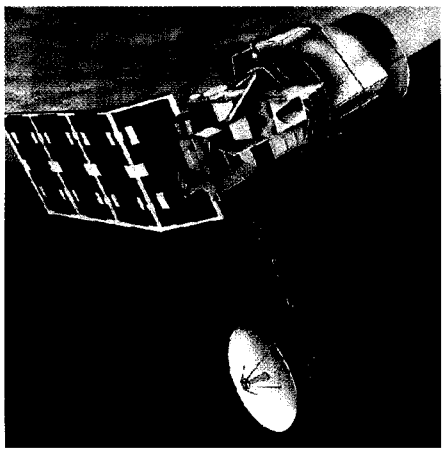


***NAVSTAR* Global Positioning System.**

Another category of satellites is the Natural Resources Satellites. They locate natural resources and monitor other conditions on the Earth's surface. This is the task of the **LANDSAT** series of satellites. Some of the missions of *Landsats* are: measure and record radiant energy, monitor agricultural conditions, aid urban planners in future development and management of coastal resources.

Another area where satellites have had a dramatic impact on our lives is in weather. Weather satellites have significantly upgraded the capability and accuracy of weather information. This in turn gives us timely information which we can use for making daily decisions. The first weather satellite, *Tiros 1*, was launched in 1960. Since then, weather satellites have come a long way. The pictures we see on television weather reports come from Geostationary Operational Environmental Satellites **(GOES).** GOES gives us pictures of the Earth's surface, pictures of clouds and provides information which helps with weather forecasting.

NASA sent the first weather satellite, Tiros I, into space on April 1, 1960. It sent back an image of a hurricane that same day. Weather satellites have come a long way since then. The weather satellites of today have tremendously added to the accuracy of our weather forecasters. They provide the technology and information that have particularly helped with forecasting severe weather. Accurately predicting severe weather saves property and lives.



***LANDSAT*: a Natural Resources Satellite.**

***LANDSAT* 4 image shows the Gulf Coast of southern Louisiana and Mississippi.**

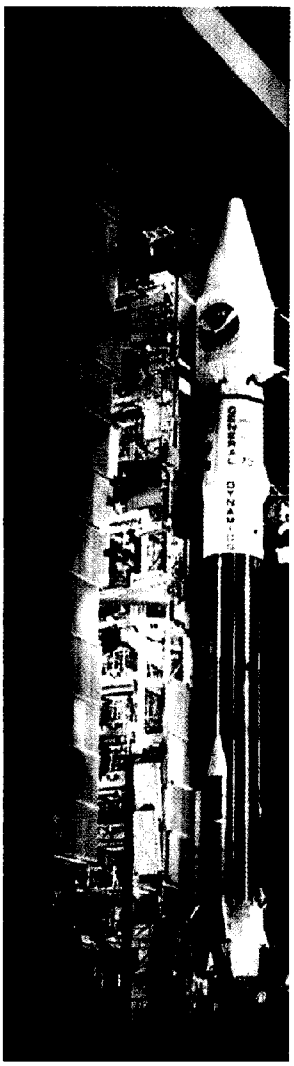
Over the years, satellites have been used for obtaining scientific information in an effort to gain a better understanding of space. Here are a few of the most important satellites and their missions. *Explorer* was the first and oldest US satellite series. *Explorer* 1 was launched in 1958. It discovered the Van Allen radiation belts. Later that year, *Explorer* 3 provided more information about radiation in space and investigated the presence of micrometeoroids. In 1959, *Explorer* 6 gave us our first photograph of Earth from space.

One group of satellites, the **Orbiting Solar Observatory (OSO)**, provided continuous solar observations for most of the 1960s and 1970s. The OSO series also furthered our studies of x-rays, gamma rays and ultraviolet rays.

The early hurricane imagery from *Tiros* I.

Satellites or spacecraft that either fly by, orbit or land on a celestial body, other than Earth, are called **space probes**. We've had several probes that we should briefly mention. The ***Rangers*** were the first probes to take pictures of the Moon in preparation for the *Apollo* landings. The ***Mariner*** series flew by Venus and Mercury and gave us pictures of Venus' clouds and Mercury's cratered surface.

In the 1970s, the ***Pioneer*** probes gave us pictures of Jupiter and Saturn. In 1975, the ***Viking*** series explored the environment of Mars. The Vikings analyzed and photographed Mars' surface with the primary emphasis on the search for life. In the late 1970s, ***Voyager* 1** and **2** also encountered Jupiter and Saturn. The *Voyagers* provided greatly improved pictures and data of these two planets.



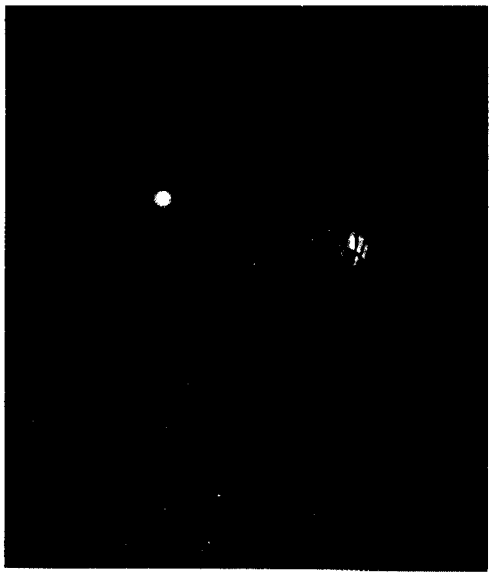
← *GOES* 8 weather satellite atop and *Atlas* I rocket being prepared for launch in 1994.

Satellites As a System

Satellites as a system refers to a satellite's related parts in a set or a system. These systems are made up of **people**, the **space environment** in which they orbit, **sub-systems** that support the spacecraft in space, an Earth-bound and a space **command and control** system, and finally, a means to get the spacecraft to orbit, a **launch**.

There are many people involved in the design, manufacture, launch and operation of any satellite. Plus, this category also includes the customers. As users of the information, they define the overall purpose and requirements for the satellites.

The space environment is something we can't control. It is extremely dangerous for both humans and satellites. For satellites, atmosphere is a concern because low Earth orbiting satellites must battle atmospheric drag, and of course gravity, which will continue to pull the satellites toward Earth. Radiation, charged particles and solar flares are also potentially dangerous for satellites. Radiation is heat energy emitted from the sun that is both good

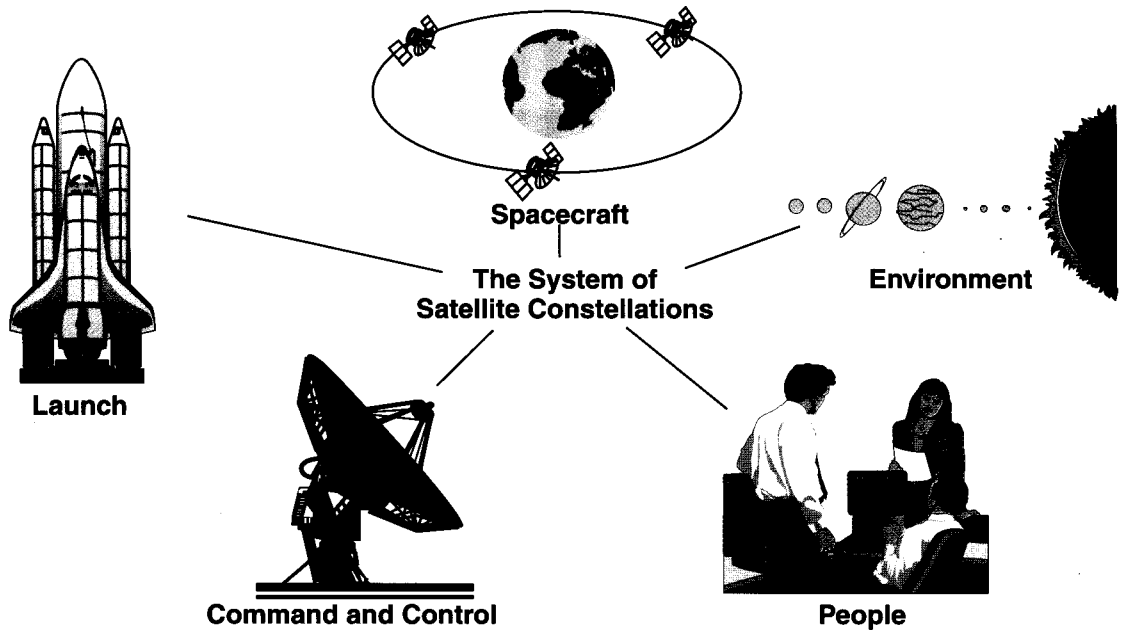


Pioneer **leaving our solar system.**

Voyager **provided pictures of Saturn and Jupiter.**

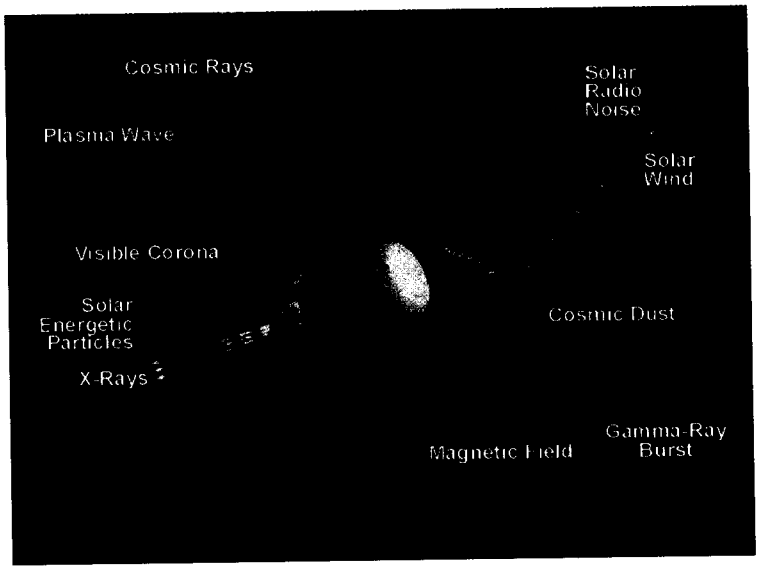
and bad. The heat gives energy to the solar-powered satellites, but can bring harm to the satellite's protective coatings over time. The same is true with charged particles and solar flares. Over time these phenomena can harm the satellite's protective shields and damage electrical equipment.

Micrometeorites and space debris can also harm satellites. Some 20,000 tons of natural materials makes it into the Earth's atmosphere every year. Most of it burns up, but some does hit the Earth. Manmade debris or junk is also a threat. It is estimated there are over a billion tiny pieces of junk, such as slivers of metal and paint chips in space. Why do we care? We care because in 1983 a paint chip of .008 inches hit the Space Shuttle Challenger and caused a crater twenty times its size (.16 inches) in an orbiter window. Traveling at over 1500 miles per hour at impact, a paint chip has tremendous energy. Efforts are underway to minimize the amount of debris each mission leaves behind.

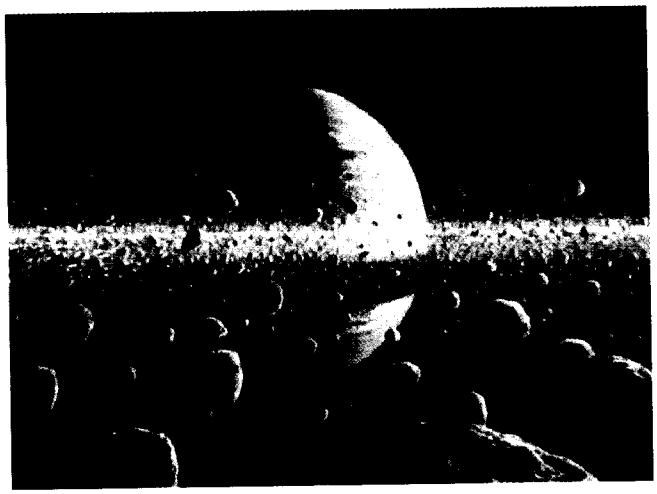


The **sub-systems** refer to the support that is given to the spacecraft in space. These include the **structure**, the **propulsion system**, **attitude control**, the **power system**, **thermal control** and a **command and control system**.

The first aspect that ties the sub-systems together is the satellite's mission. The mission defines the satellite's purpose, what services will be provided, why the satellite is being built and how it should be designed. The first step of the design is to determine the payload requirements. The payload refers to the sensors and instruments used to perform the mission, which also determine the other requirements of the satellite.



Space Environment



Asteroids

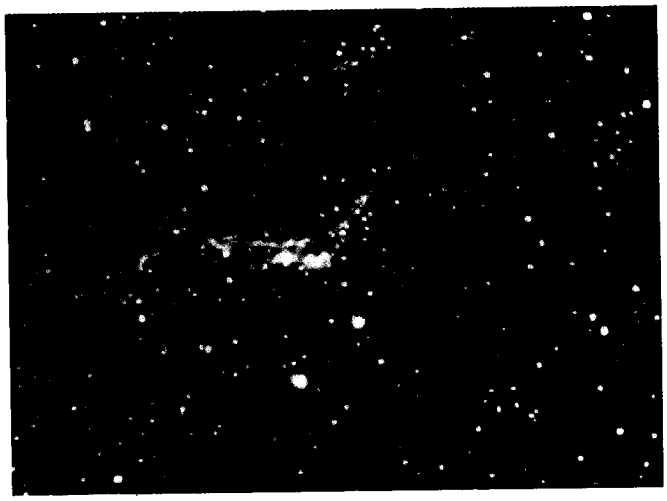
The structure of a satellite is like a building. It has a frame and windows, and it is insulated to help control the temperature. It must be sturdy enough to survive the launch, yet light enough to get into orbit. It supplies the support for the other sub-systems.

The propulsion system provides the boost to get the satellite into orbit. It takes an enormous amount of power to get into the correct orbit and stay there.

To make minor corrections in direction, the attitude control system is used. It steers and controls where the satellite is pointed.

Obviously, the power is another important sub-system, and electrical power is the essential ingredient. The main source of electricity while the satellite is in orbit is the Sun. The solar power is collected from the satellite's solar cells and converted to energy to power the satellite.

A satellite experiences extreme temperature differences while in orbit. There are times when the Earth moves between a satellite and the Sun. When this happens, the temperature drops dramatically. Many measures can be used to control the temperature, but the most common are



Dust in Space

insulation and heaters. Both of these help keep the temperature within safe limits. This temperature data is all part of the thermal control sub-system.

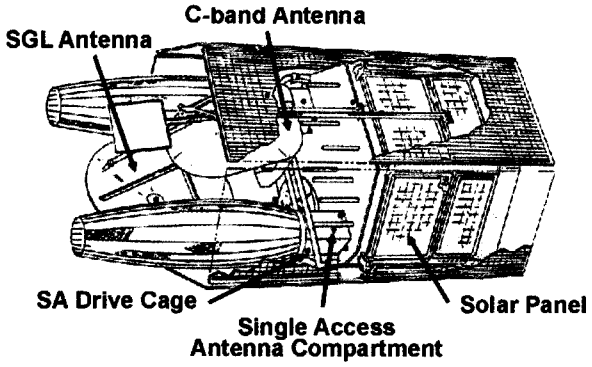
The command and control function of a satellite is a communication system. The command portion is the signal from the ground station to the satellite. The commands sent to the satellite are computer programs. The satellite collects the information and sends it back to the ground station. This is called telemetry and this is the information that tells a controller how the satellite is functioning.

The last part of the system is the launch, which gets the satellite into orbit. The mission requirements determine the orbit needed to accomplish the mission. To meet these requirements, a satellite must be launched from a particular launch site at a particular time. There is a launch window in which this can occur, but it is usually a short period of time. There may be only one or two launch windows per day.

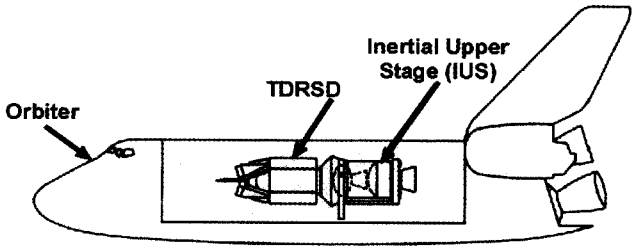
Orbits and Trajectories

An **orbit** is the movement or path a satellite takes around a celestial body. We commonly call any object that orbits the Earth a satellite. Studying the orbital motion of satellites helps us understand the capabilities and limitations of these satellites.

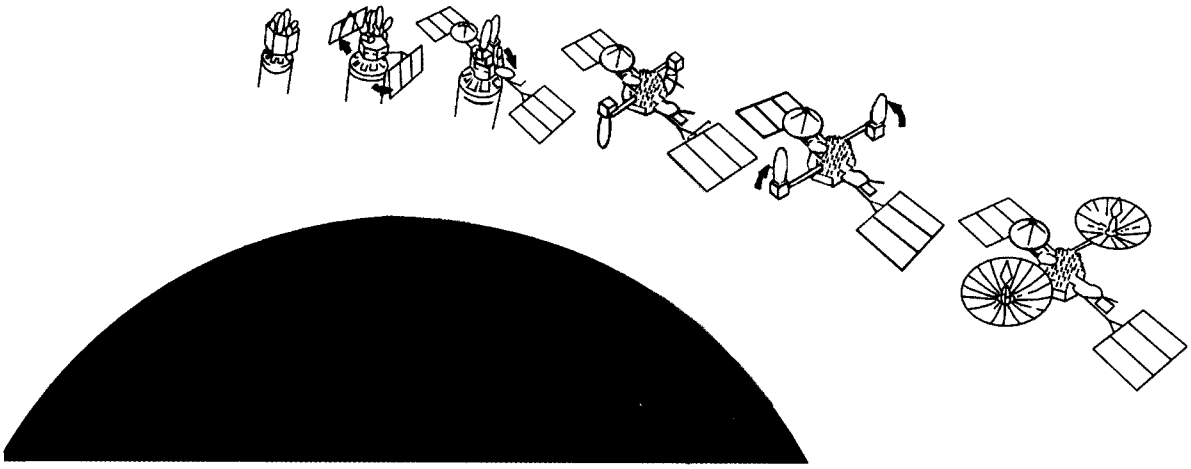
Greek astronomer Ptolemy (A.D. 127-145) gave us the first theory of motion of celestial bodies. His theory, the geocentric theory, placed the Earth at the center of the universe. He was wrong, but it was the first organized concept of the motion of celestial bodies. Celestial bodies are planets, stars, comets and



A Folded TDRSS Satellite



TDRSS Satellite Tucked Neatly into the Cargo Bay of the *Space Shuttle*



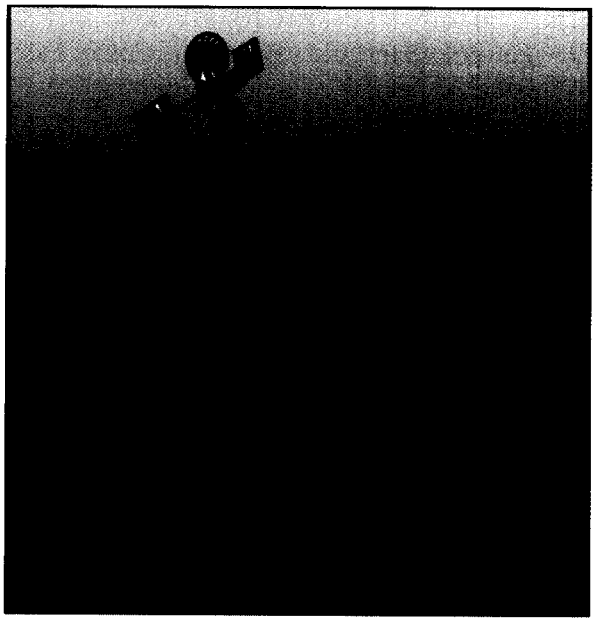
The Satellite unfolds until its antennas and solar panels stretch to dimensions larger than the size if a house.

any other large objects in space.

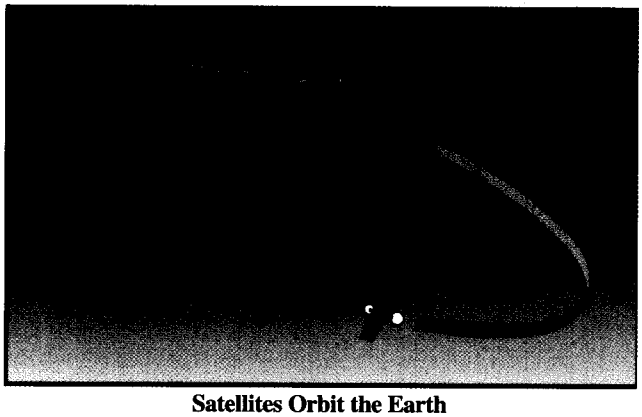
In the 1400s, Copernicus developed a heliocentric theory of the universe. This theory placed the Sun at the center, and all the rest of the universe revolved around it. Copernicus was not entirely correct, because the universe does not revolve around the Sun as do the planets and other objects inside our solar system.

These ancient astronomers determined that the motion of celestial bodies was not random. Kepler studied the motion and measured the movement of planets. In the 1600s, he created rules of motion which we call Kepler's laws. All celestial bodies, including artificial satellites, obey Kepler's laws. Kepler's First Law states: The orbit of each planet is an ellipse, with the Sun at the focus.

In an elliptical orbit, the satellite's altitude, velocity and speed are not constant.Therefore, the shape varies. The shape can range from being very elliptical to almost circular.



Telemetry



Satellites Orbit the Earth

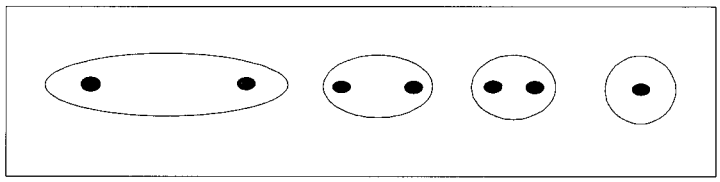
During an orbit, the orbiting object reaches a high point and a low point. Its highest point is called the **apogee**, and its lowest point is called its **perigee.** The apogee represents the point where the object is the farthest away from the body being orbited. The perigee represents the point where the object is the closest.

See Activity One - Why Do Satellites Stay in Orbit?
Refer to the Activity Section at the end of the chapter for this activity.

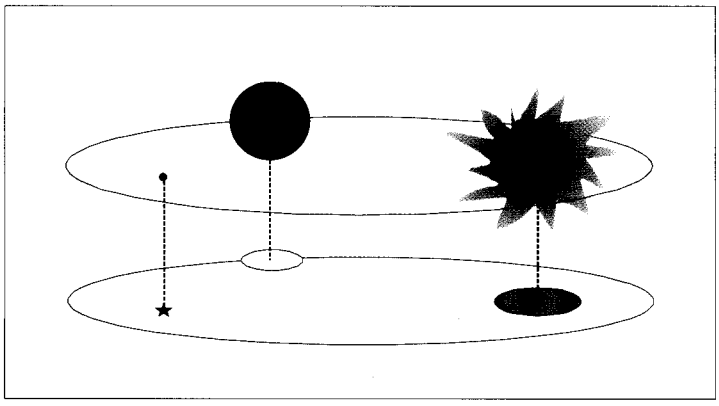
See Activity Two - Escape Velocity
Refer to the Activity Section at the end of the chapter for this activity.

Copernicus

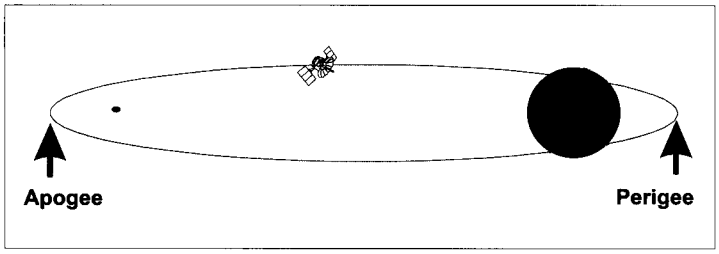
Several years after Kepler, Sir Isaac Newton developed his laws of motion. Newton's laws of motion are very helpful to understanding the movement of satellites. These laws are discussed in detail in Module Four, *Rockets*. However, I'll briefly mention another of Newton's laws, the Law of Universal Gravitation. This law explains the gravitational attraction or pull between bodies in the universe. The Earth's gravitational force is always toward the center of the planet. The Earth's gravity is the dominant force

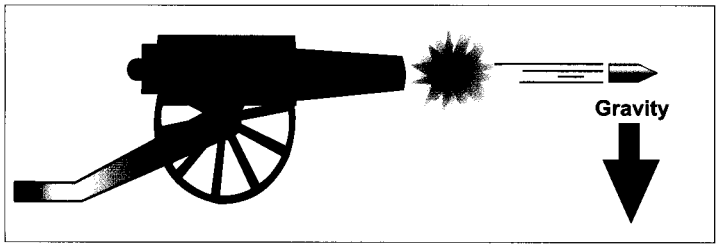


Orbital Shapes



Elliptical Orbit

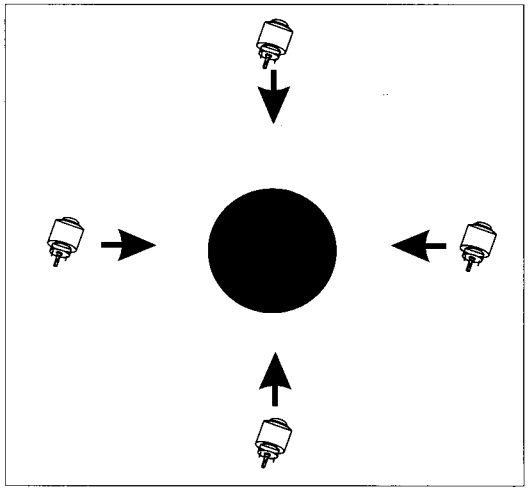




Gravity pulls the bullet toward the center of the Earth.

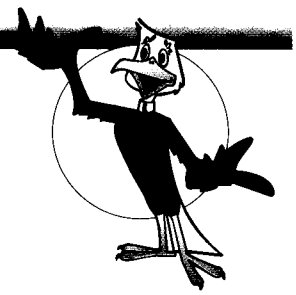
affecting the motion of a satellite in an Earth orbit.

Gravity gives the orbit its shape. An example of a bullet fired from a gun helps to explain this. As the bullet is traveling in a straight line, gravity pulls the bullet toward the center of the Earth. The combination of the bullet's speed and gravity creates a curved flight path.



The Earth's gravitational force is always toward the center of the planet.

QUESTIONS : Chapter One



What is a satellite?
What is the shape of an orbit?

THINGS TO REMEMBER

Familiarizing yourself with satellites and their orbits gives you a good foundation for understanding how far we have come in this area. Remember that the Moon is the natural satellite of Earth. There are many types of artificial satellites that are in use today that greatly impact our lives.

REVIEW QUESTIONS

1. Whose scientific law says that each planet's orbit is an ellipse with the Sun at the focus?
   a. Kepler
   b. Copernicus
   c. Ptolemy
   d. Newton

2. Which sub-system of a satellite provides a boost to get the satellite in orbit?
   a. The structure
   b. The propulsion
   c. The attitude control
   d. The command and control

3. Which of the following is a part of a satellite system?
   a. People
   b. Space environment
   c. Sub-systems
   d. All of the above

2 MANNED SPACECRAFT

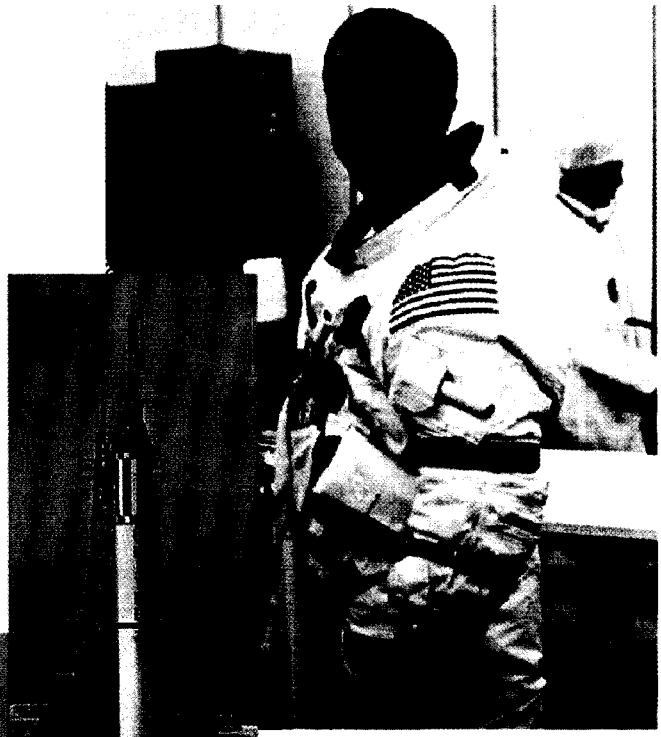
Important Terms

Mercury - US' first manned spaceflight project
Gemini - US' manned spaceflight project that achieved the first walk in space, and the first two-man capsule
Apollo -US' manned spaceflight project that put man on the Moon
Skylab -US' manned spaceflight project that put a laboratory into space
Apollo-Soyuz - manned spaceflight project linking American and Soviet spacecraft in space
Space Shuttle -US' Space Transportation System (STS) for transporting into space and returning to Earth

PROJECT MERCURY

The United States launched its first satellite in 1958, and by 1961 the US was ready to attempt manned spaceflight. America's first manned spaceflight program was called **Project Mercury**. Mercury's mission was to find out if a human could survive space travel, and what, if any, effects would space travel have on the human body.

Project Mercury lasted two years and consisted of six manned flights. The first flight involved sending one astronaut into space. This first flight was suborbital and lasted for only 15 minutes, but on May 5, 1961, astronaut Alan Shepard became the first American in space.



Alan Shepard suiting up before first manned space flight.

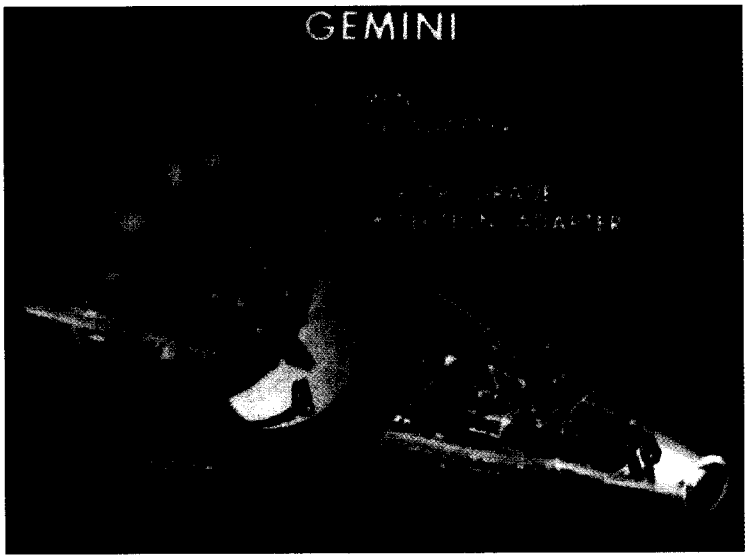
← ***Freedom* 7, ready to carry Shepard into space.**

← **Cutaway of the *Mercury* capsule.**

Project Mercury's third manned flight was also its first orbital flight. During this flight, astronaut John Glenn became the first American to orbit the Earth. He remained in orbit for four hours and fifty-five minutes, while orbiting the Earth three times.

On the final Mercury flight, astronaut Gordon Cooper orbited the Earth 22 times and stayed in space for about 34 hours and 20 minutes. Project Mercury answered the basic questions about survival in space. Project Mercury accomplished its mission.

John Glenn enters his capsule *Friendship* 7.

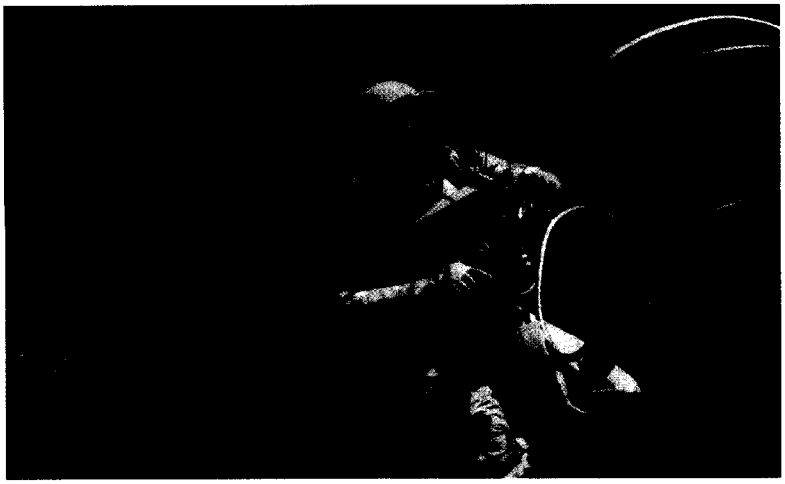


The two-man *Gemini* capsule

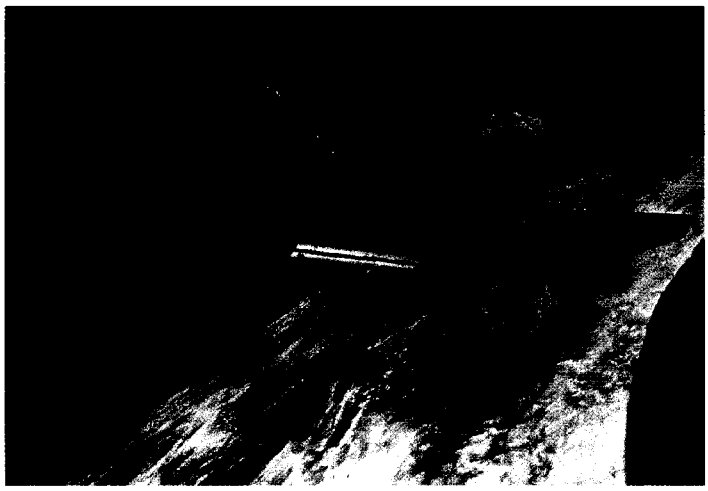
PROJECT GEMINI

The next manned spaceflight project was **Project Gemini**. There were a total of 10 Gemini flights. Gemini was the first two-man capsule, and it also achieved the first walk in space. Additionally, Gemini was the first rendezvous and docking of a manned spacecraft with another satellite.

The Gemini flights gathered additional information about the effect of spaceflight on the human body. The astronauts studied the effects of weightlessness and were involved in an exercise program. At times, they removed their space suits and relaxed in shirt sleeves. Because the flights lasted for several days, the astronauts were able to establish routines for sleeping and eating. Enough information was gathered to convince scientists that a space flight could safely last for several weeks or even months. These Gemini flights were very valuable in America's plan of placing a man on the Moon.



***Gemini* IV's astronaut Ed White made a 22-minute space walk.**



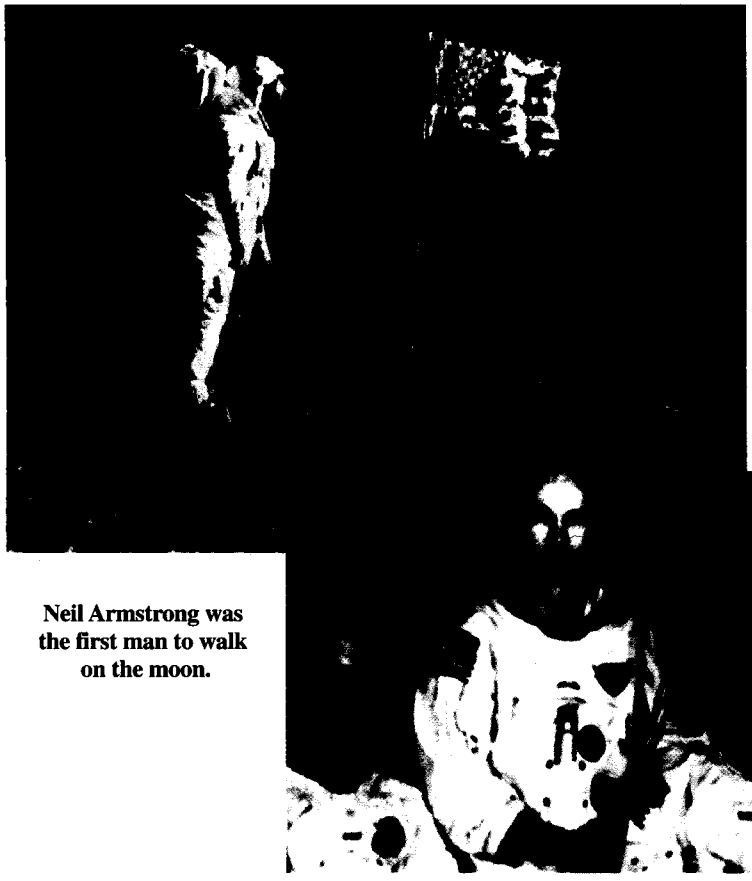
***Gemini* IX rendezvous target, dubbed the "angry alligator," failed to open fully.**

PROJECT APOLLO

After the Gemini missions were completed, **Project Apollo** took center stage in America's space program. From the early 1960s, it was known that Apollo's mission would be to put a man on the Moon. So, the Apollo flights were conducted with that overall goal in mind. Several of the early Apollo flights traveled to the Moon, orbited it and returned to Earth. It was not until *Apollo* 11 that the mission was accomplished. *Apollo* 11 landed on the Moon, and on July 20, 1969, Neil Armstrong was the first man to walk on the Moon.

A few minutes later, Edwin "Buzz" Aldrin also stepped off the ladder of the Lunar Module and joined Armstrong on the Moon. Many have called that landing the greatest scientific and engineering accomplishment in history. After *Apollo* 11, there were six more Apollo flights to the Moon. Five of them resulted in successful Moon landings.

The only flight of the six that didn't land on the Moon was *Apollo* 13. *Apollo* 13 had to be aborted due to an explosion in the spacecraft. However, *Apollo* 13 did make a successful emergency landing back on Earth.



Neil Armstrong was the first man to walk on the moon.

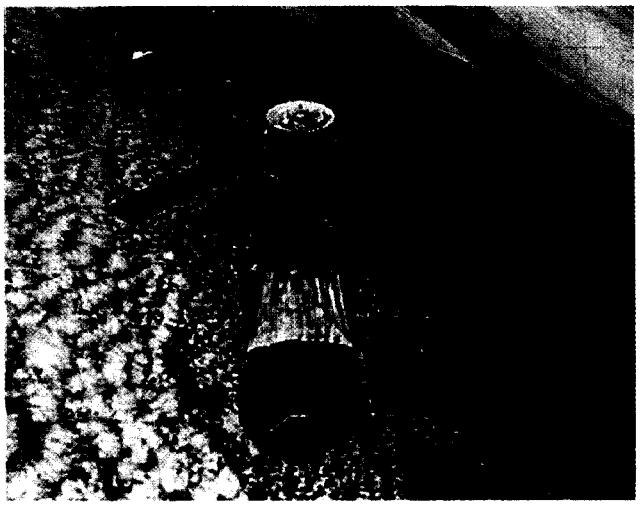
Aldrin joins Armstrong on the moon.

← The *Apollo* 11 astronauts, Michael Collins, Edwin E. "Buzz" Aldrin, and Neil A. Armstrong

"Houston, we have a problem."

See Activity One - See How the Earth Looks to an Astronaut
Refer to the Activity Section at the end of the chapter for this activity.

See Activity Two - Earth -- Moon Distance
Refer to the Activity Section at the end of the chapter for this activity.



Skylab

PROJECT SKYLAB

Project **Skylab,** the next spaceflight project, used a lot of leftover equipment from the Apollo missions. Skylab's mission was to put a laboratory into space. Scientists had been interested in continuing their studies of the effects of long-duration space flights using a manned orbiting laboratory. This was accomplished when *Skylab* was launched in May 1973.

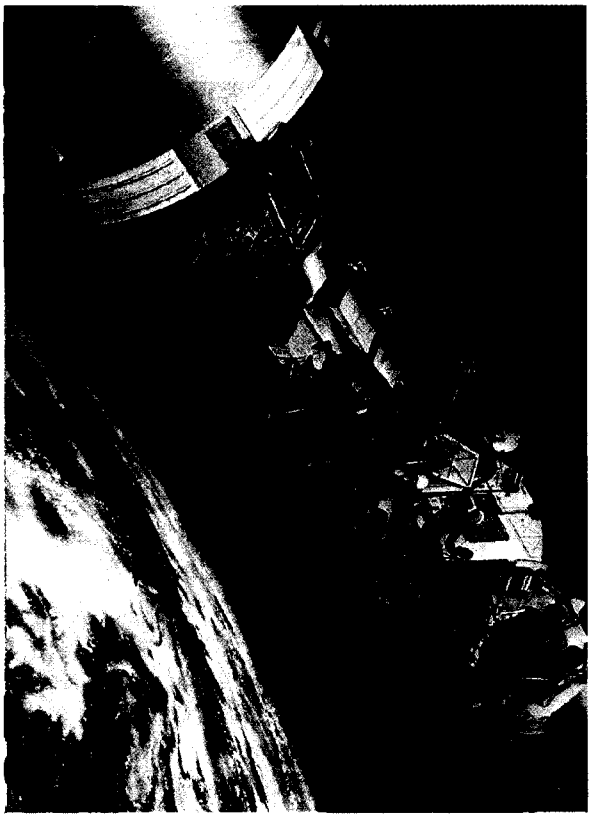
Skylab had about the same amount of room as a three-bedroom house. It also contained all of the food, water and oxygen needed to support the entire mission.

Three different crews spent time in the lab. The first crew manned *Skylab* for 28 days. The second crew spent 58 days aboard the laboratory. The final crew spent 84 days in space. The main lesson that came from *Skylab* was that people could live and work in space for at least three months with no ill effects.

PROJECT APOLLO-SOYUZ

After the Apollo flights, the last manned space launch before the *Space Shuttle* was the ***Apollo-Soyuz* Test Project**. This occurred in July 1975 and involved a linkup in space of an American and a Soviet manned spacecraft. This was a unique moment in history. These two superpowers, that had been involved in a well-publicized space race for 15 years, met and shook hands in space. This was indeed a special moment.

The two crews docked together and spent two days moving between the capsules helping each other with scientific experiments. Among the American crew were former Mercury and Gemini astronauts. Among the Soviet crew was Aleksei Leonov, the first man to walk in space. Back in 1965, Leonov



The Apollo-Soyuz project depicted in this illustration.

payload. The other two parts are required to launch the shuttle into space. The boosters burn away and the tank separates early into the flight.

When the shuttle was first built it could remain in space for 14 days. That time has increased to 30 days now. When it is time for the shuttle to return to Earth the astronauts fire the two orbital maneuvering engines, which slows down the shuttle. The shuttle then reenters the Earth's atmosphere.

The first Space Shuttle was actually the *Enterprise,* but it was only used for flight tests. It was not designed for going into space. The other five Space Shuttle spacecraft have all gone into space and have been used for a variety of missions. They are the *Columbia*, *Challenger*, *Discovery*, *Atlantis* and *Endeavour*.

The first four flights of the *Columbia* were mainly tests. Most of the concern centered around how the *Columbia* would handle reentry into the Earth's atmosphere and how its protective shields would perform. STS-5 was the first real operational flight, and it occurred in November 1982. From orbit, the STS-5 launched two satellites.

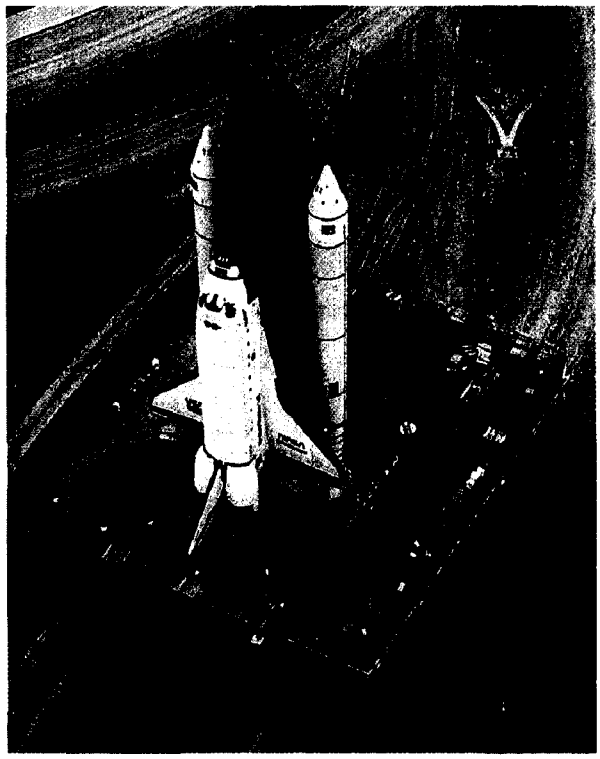
walked in space two months prior to the American walk in space. This joint venture truly was an historic event.

Apollo-Soyuz marked the end of an era. It marked the end of the expendable spacecraft. A new era was being ushered in, the era of the reusable space vehicle, the *Space Shuttle.*

SPACE SHUTTLE

From 1975 until 1981, the US didn't have any astronauts in space, but that changed with the Space Shuttle. In April 1981, The Space Transportation System (STS), commonly called the ***Space Shuttle***, was launched. The Space Shuttle provided a system for transportation into space and a return back to Earth. This has been a major advantage of the shuttle since it can be used again and again.

The *Space Shuttle* consists of three main parts: the orbiter, the solid rocket boosters and the external tank. The orbiter looks like an airplane and is about the same size as a *DC*-9 jet. The orbiter carries the crew and the

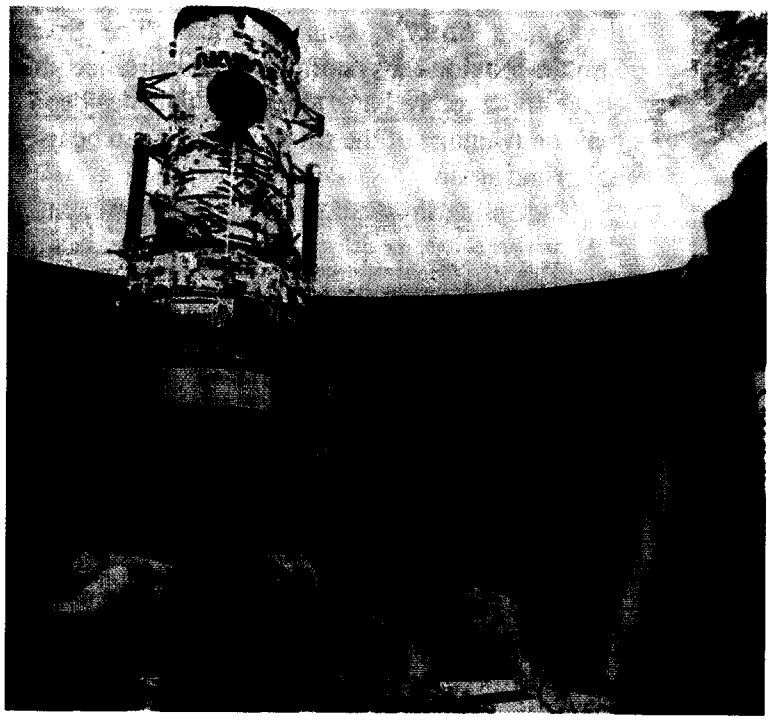


The Rollout of the Space Shuttle *Challenger* before it's first launch in 1983

Over the years, the *Space Shuttle* has been used in many ways to further our knowledge of space. The first American woman in space, Dr. Sally Ride, was aboard the *Challenger* for STS-7. STS-9 delivered the first *European Space Agency Spacelab* into space. STS-13 placed the Long Duration Exposure Facility (LDEF) into space to conduct experiments. A few years later, the LDEF was retrieved and the many experiments analyzed.

On January 28, 1986, less than two minutes after takeoff, the *Challenger* (STS-25) exploded. The entire crew of seven died. A leak in one of the solid rocket boosters was the cause. After the *Challenger* accident, the shuttle program was suspended for over two years. After design changes were made, and safety procedures and precautions taken, on September 29, 1988 the *Space Shuttle* flights resumed.

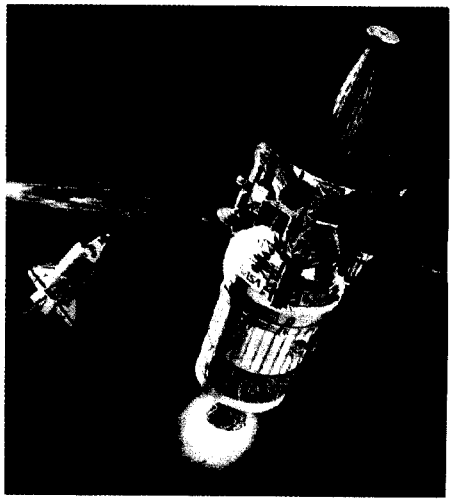
Dr. Sally Ride, first American woman in space, with the crew of the *Challenger* mission STS-7.



Two Astronauts repair and service the Space Telescope *Hubble*

In April 1990, the shuttle *Discovery* deployed the ***Hubble Space Telescope***. The *Hubble Telescope* is operating at over 300 miles above the Earth and is free of any atmospheric interference. Therefore, the objects are seen much more clearly than from ground observations. The telescope is expected to operate for about 15 years. However, the *Space Shuttle* can retrieve it, repair it and return it to orbit for continued use.

Atlantis, with mission STS-34, placed the Galileo probe into space. The Galileo probe is investigating Jupiter for six years. In 1993, STS-55 carried the European developed *Spacelab* into orbit. Many useful experiments were conducted from the *Spacelab.*



As you can tell from the few examples that have been mentioned, the *Space Shuttle* was designed to be the workhorse of our space program, and indeed it has been. The *Space Shuttle* has had about 100 missions so far, and it has served our nation well. Our knowledge of space has increased tremendously with the help of the *Space Shuttle.*

***Atlantis* launches *Galileo* probe into space.** ⟶

SOVIET UNION'S MANNED SPACE PROGRAM

The Soviet Union's space flight programs developed along the same lines as the American programs and occurred approximately the same times. However, the Soviets had several firsts in the space race.

In 1957, the Soviets launched the first satellite, *Sputnik*, into space. After that, the Soviets launched nine more *Sputniks* in about 3 ½ years. The last two were accomplished in preparation for their first manned space flight.

The Soviets also put the first man in space in April 1961. Major Yuri Gagarin was the first man to escape the Earth's atmosphere. Although he only stayed up for one orbit, he described sights no human eyes had ever seen before. Then in June 1963, the Soviets put the first woman, Valentina Tereshkova, into space. She completed 48 orbits and was in space for three days before returning safely to Earth.

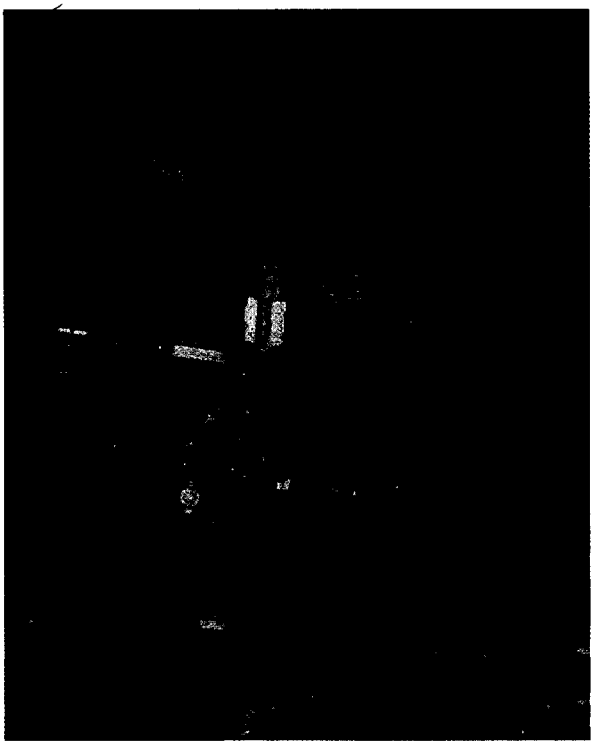
Yuri Gagarin, the First Man in Space

In March 1965, Alexei Leonov became the first person to "walk in space." He spent 20 minutes outside of his spacecraft. This occurred about two months before the Americans walked in space.

The Soviets launched their first space station, *Salyut* 1, in April 1971. The Soviets sent seven *Salyuts* into space to complete their space station missions. *Salyut* 7 fell back to Earth in 1991.

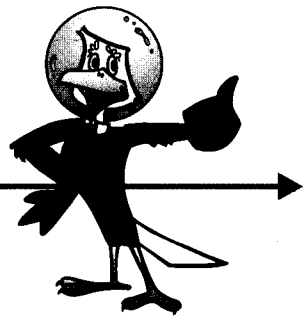
The Soviets next space station model was *Mir*. *Mir* was launched in February 1986. *Mir* doesn't carry as many specific instruments, so there is more room and comfort for the cosmonauts. In 1998, the United States sent several space shuttles to dock with *Mir*. American astronauts have spent over two years aboard *Mir* on different occasions.

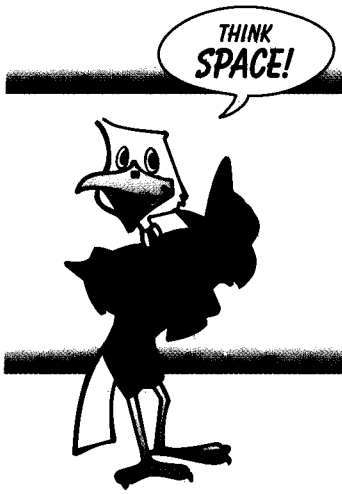
Mir was scheduled to fall to Earth in 1999. However, the Soviets boosted *Mir* so that it would stay in space through the year 2000.



—— **The Soviet Space Station, *Mir***

See Activity Three - The Space Shuttle Glider
Refer to the Activity Section at the end of the chapter for this activity.





QUESTIONS: Chapter 2

- What were the names of the five manned space flight projects prior to the Space Shuttle?
- Which manned spacecraft project was responsible for putting a man on the Moon?

THINGS TO REMEMBER

You should remember the five manned space projects and their missions. They were the pioneers of our current space program. The Apollo program is particularly significant because it gave us the Moon landing. The success of these early manned programs led to the use of the space shuttle. Don't forget to refer to the Activity Section.

REVIEW QUESTIONS

1. Which project was involved in the American and Soviet linkup in space?
   a. *Skylab*
   b *Gemini*
   c. *Mercury*
   d. *Apollo-Soyuz*

2. Who was the first man to set foot on the Moon?
   a. Chuck Yeager
   b. Alan Shepard
   c. John Glenn
   d. Neil Armstrong

3. The first commercial satellite was called
   a. Tiros.
   b. Explore.
   c. Telstar.
   d. Navstar.

3 LIVING AND WORKING IN SPACE

Important Terms

Space Station Alpha - Future space station, a joint venture with US, Europe, Canada, Japan and Russia
Mir - Russia's space station of the 1980s and 1990s
Salyut - Russia's first space station
Skylab - US' first space station
Spacelab - European Space Agency's first space station

As we learned in Chapter 2, the Space Shuttle has made around 100 trips into space. Many of those flights involved space laboratories that conducted experiments about living and working in space. In this chapter, we will learn more about what it is really like living in space.

SPACE STATIONS

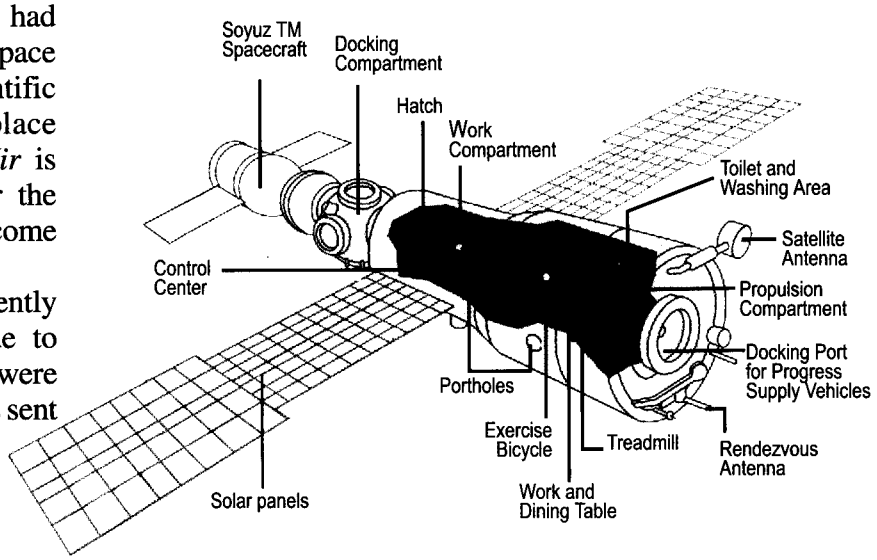
The idea of a permanent space station has been with us since the beginning of the space race. The benefit of having a way station en route to the Moon or the planets has been recognized for some time. For scientific, research and even military reasons, a permanent space station has been considered a necessity.

Russia launched the first space station, *Salyut 1* in April 1971. Russian astronauts docked and stayed on board for three weeks. *Salyut 1* stayed in space for six months, then burned up when it reentered the Earth's atmosphere.

Russia continued to launch several space stations in the **Salyut** series. Many of the missions resulted in Russian astronauts staying in space for 1-2 months. *Salyut 6* and *7* both stayed in space about four years. The astronauts stayed aboard *Salyut 7* for a record 234 days.

The success of the *Salyut* series brought on the next model of Russian space station, the ***Mir***. *Mir* was launched in February 1986 and was about the same size as *Salyut*. However, *Mir* didn't carry as much scientific equipment, so it had more privacy, comfort and space for the astronauts. Scientific experiments still take place aboard *Mir*, but mainly *Mir* is used as living quarters for the Russian astronauts who come and go in space.

In 1998, *Mir* was frequently in the news. This was due to several malfunctions that were occurring. The United States sent the *Space Shuttle* to *Mir* several times to help with repairs. In fact, American astronauts have spent over two years aboard *Mir* on

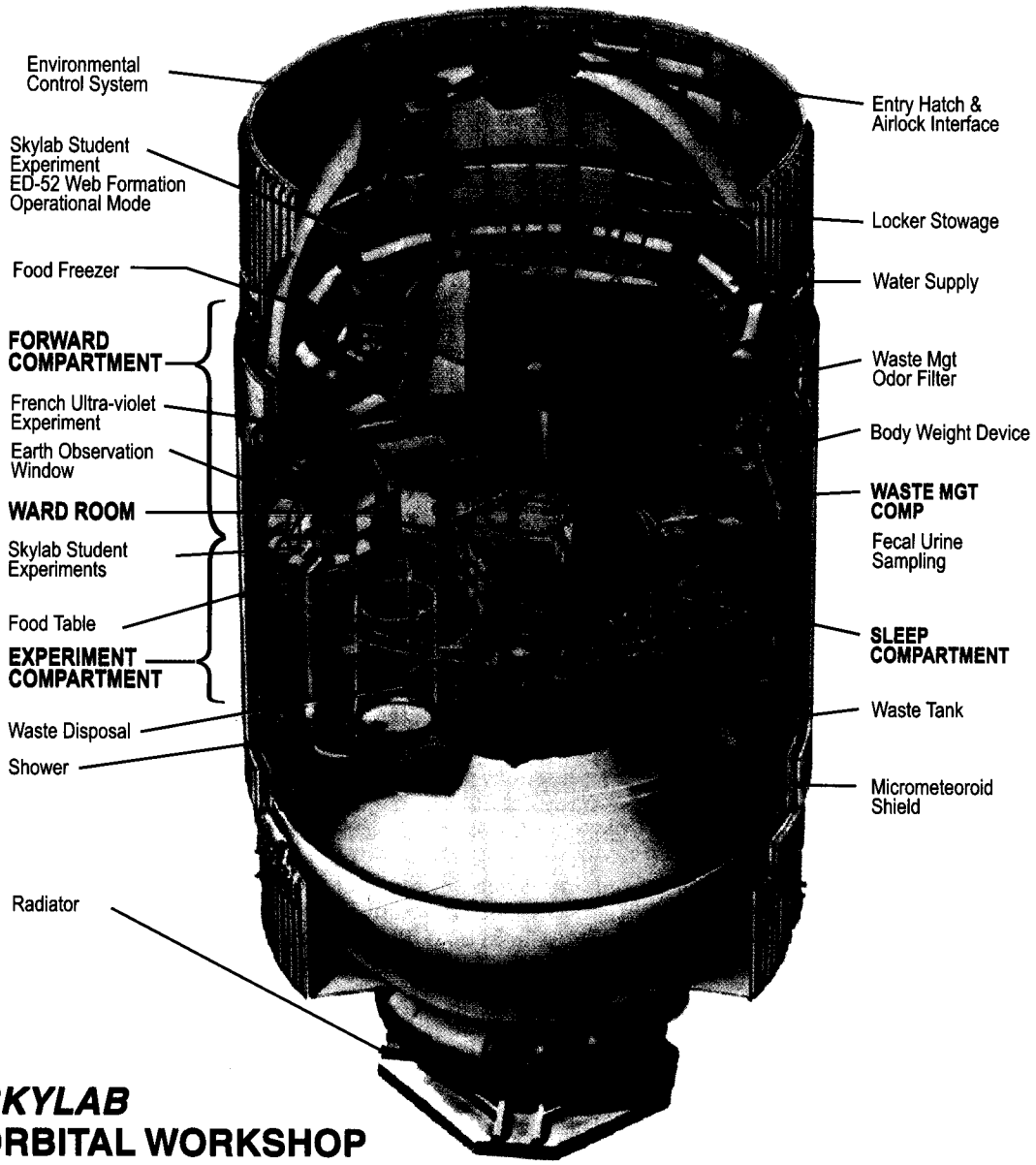


The *Mir* Space Station

different missions. *Mir* was scheduled to fall back to Earth in 1999. However, The Russians boosted *Mir* to stay in space longer. So, despite problems through the early months of the year 2000, *Mir* remains in space.

The US' first space station was ***Skylab***. As mentioned earlier, it was launched in May 1973 two years after *Salyut*. Three different crews lived in the *Skylab*. The last crew stayed for 84 days, which was the longest of the crews. During their stays, the crews conducted many experiments. They demonstrated that people could live and work in space. No other crews visited *Skylab*, but it remained in space for six years before reentering Earth's atmosphere and falling back to Earth. Most of *Skylab* burned up on reentry, but some pieces landed in the Indian Ocean and were recovered.

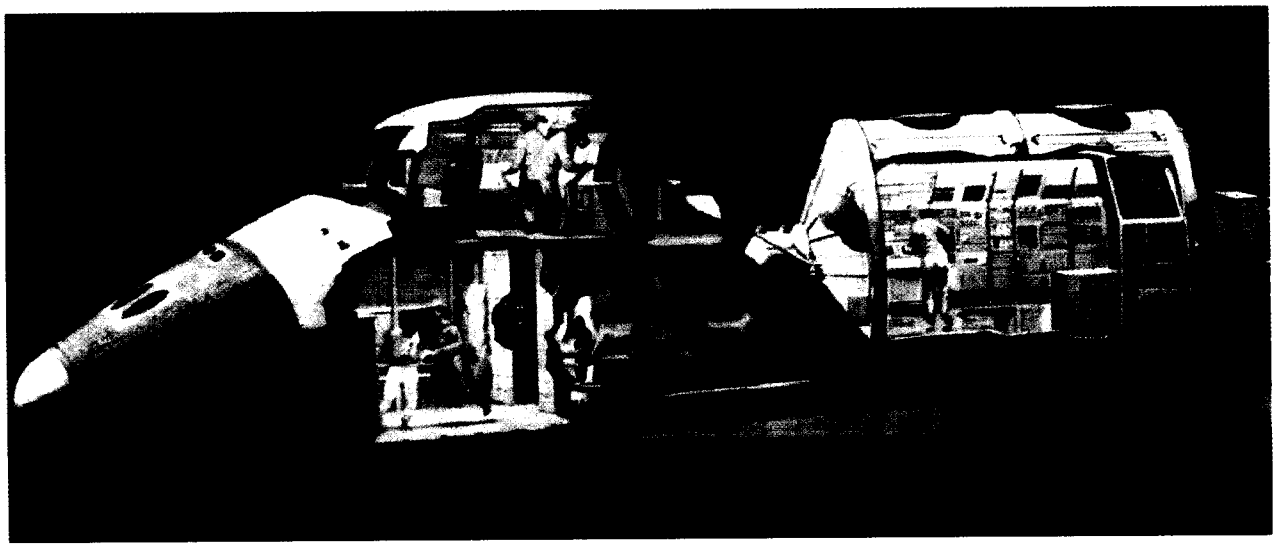
The next space station was the European Space Agency's ***Spacelab***. It continued conducting similar experiments in space, but from inside the Space Shuttle, *Columbia*. *Spacelab* was never in space more than thirty days. On one of its missions it placed the *Long Duration Exposure Facility (LDEF)* in orbit. The *LDEF* was designed to provide longer exposures to researchers.



SKYLAB
ORBITAL WORKSHOP

LIVING AND WORKING ON SPACE STATIONS

What was it like inside the space stations? Well, first of all, zero gravity or weightlessness exists inside the space stations. We have probably all seen pictures of astronauts floating around inside of the space stations. This is not really a problem. Astronauts have learned how to cope with weightlessness. They can hold on to the walls, or they can wear special cleats, or they can even strap themselves in if they want.

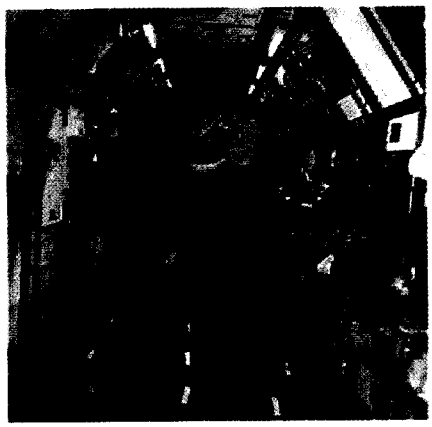


Spacelab* on board the *Space Shuttle Columbia.

The air inside the space stations is a mixture of oxygen and nitrogen. This works better than breathing pure oxygen. Also, the temperature is regulated so that the astronauts are comfortable in t-shirts and shorts or sport shirts and pants.

On the *Skylab*, the crews had a dining room, a toilet area and bedrooms. The astronauts could eat either hot or cold food. They would place their feet and legs in restraints and could actually sit and eat. Reportedly, the food has greatly improved over the years too. As for sleeping, the astronauts had sleeping bags placed vertically on the walls. They could fasten themselves in and go to sleep.

Working is also a part of life inside a space station. Astronauts have their housekeeping chores to perform. Plus, they have their research and experiments to conduct. Sometimes they have satellites to deploy or retrieve, or maybe they have to repair a satellite. Physical exercise is also a normal daily occurrence on the flights. So, there is plenty to keep the astronauts busy.

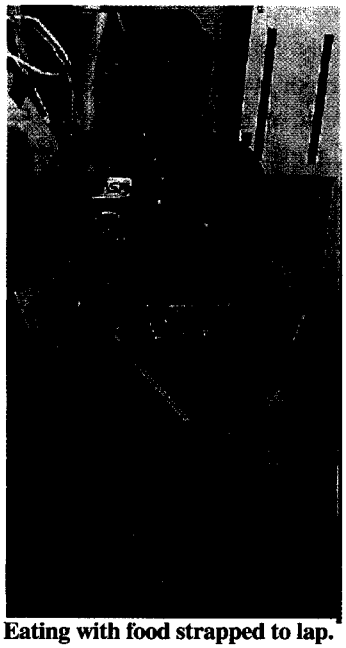


Weightless in space

Foot restraints

Extravehicular Activities (EVA)

These last few paragraphs have discussed life inside a space station. Now, let's spend a little time discussing life outside the space station. Many times a space shuttle mission will include repairing a satellite. This involves going outside of the shuttle. The general term that is used for going outside of the shuttle is **Extravehicular Activity**.

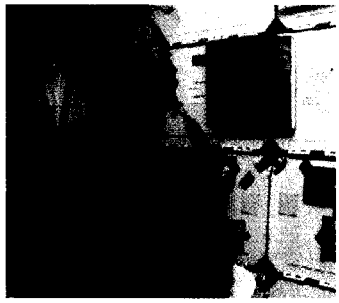


Eating with food strapped to lap.

Eating with food strapped to cabin ceiling.

Muscles must be exercised to keep them from wasting away in zero gravity.

A nice warm shower would be good.

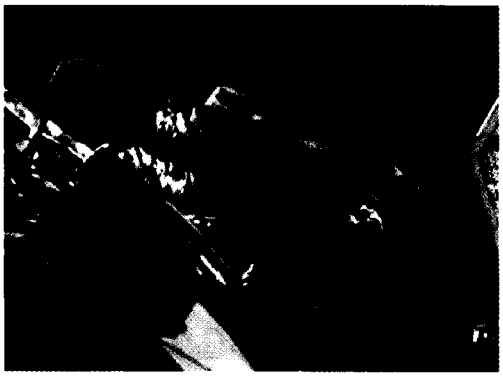


How about a shave?

Sally Ride in a sleep restraint..

Russian Aleksei Leonov accomplished the first EVA or space walk in March 1965. He was outside of his spacecraft for about 20 minutes. Less than three months later, Ed White was the first American to walk in space. This occurred in June 1965. White was outside the spacecraft for 22 minutes traveling at 18,000 miles per hour. Since 1965, there have been many EVAs in space. In 1973, *Skylab 4* set the record for the longest EVA with seven hours and one minute.

One recent EVA involved the *Hubble Space Telescope*. Astronauts made repairs to the *Hubble Telescope* during an EVA. These successful repairs will allow the telescope to stay in space longer.



An EVA near Skylab.

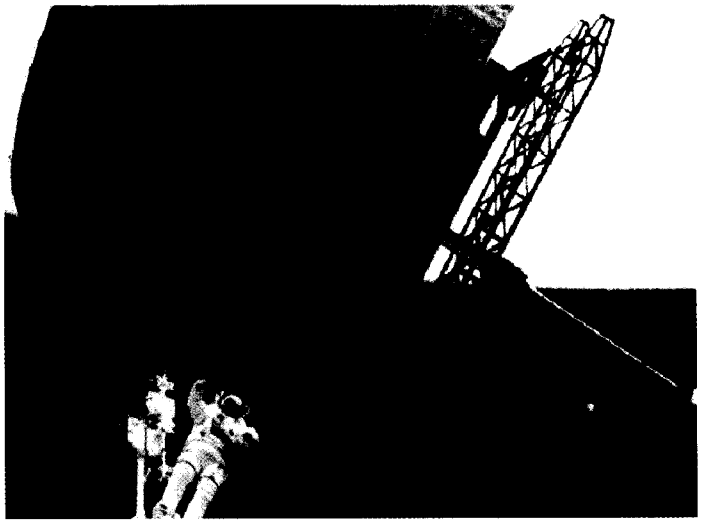
An *Atlantis* EVA.

Space Suits

Obviously, a subject that comes to mind when talking about space

walks is space suits. Space suits have changed a lot over the years. Let's take a look at the evolution of the space suit. Space suit design began in the 1930s with high-altitude flyers. These suits were really pressure suits. Over the next 30 years, the technology improved. However, the astronauts of Project Mercury actually wore pressure suits.

During the *Gemini* flights, a light weight, easily removable space suit was developed. It was during *Gemini* 7 that space suits were taken off inside of the spacecraft for the first time. Prior to that, astronauts left them on during the entire flight.



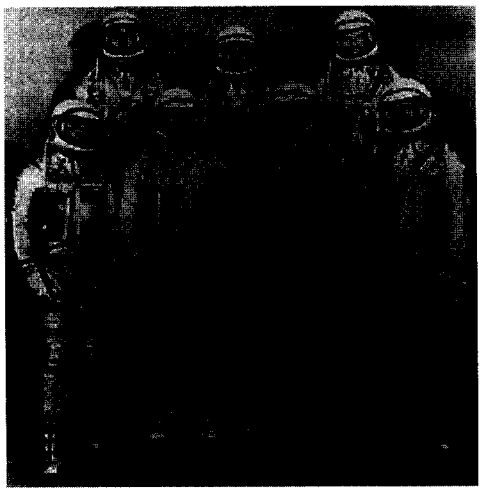
Taking a look at the Hubble Space Telescope.

Initially, the space suits were very immobile. It was hard for the astronauts to move around. However, as the space flights progressed and more was expected of the astronauts, the space suits got better. Comfort and mobility became higher priorities.

The *Apollo* moon suit was more advanced than previous suits. The astronauts carried their oxygen on their backs and could communicate as well. The suit also had a supply of drinking water and a collection point for going to the bathroom.

All of these space suits consisted of several layers of material. This protected the astronauts during their EVA. For instance, the *Apollo* suit protected the astronaut in temperatures of over 250°F, while also protecting against harmful radiation.

All of these space suits were made specifically for the individual astronaut. That changed with the *Space Shuttle*. The shuttle suit was much easier to put on. The astronauts dressed one layer at a time. The shuttle suit was made of several parts that could accommodate a man or a woman. It was also reusable and expected to last for 15 years.



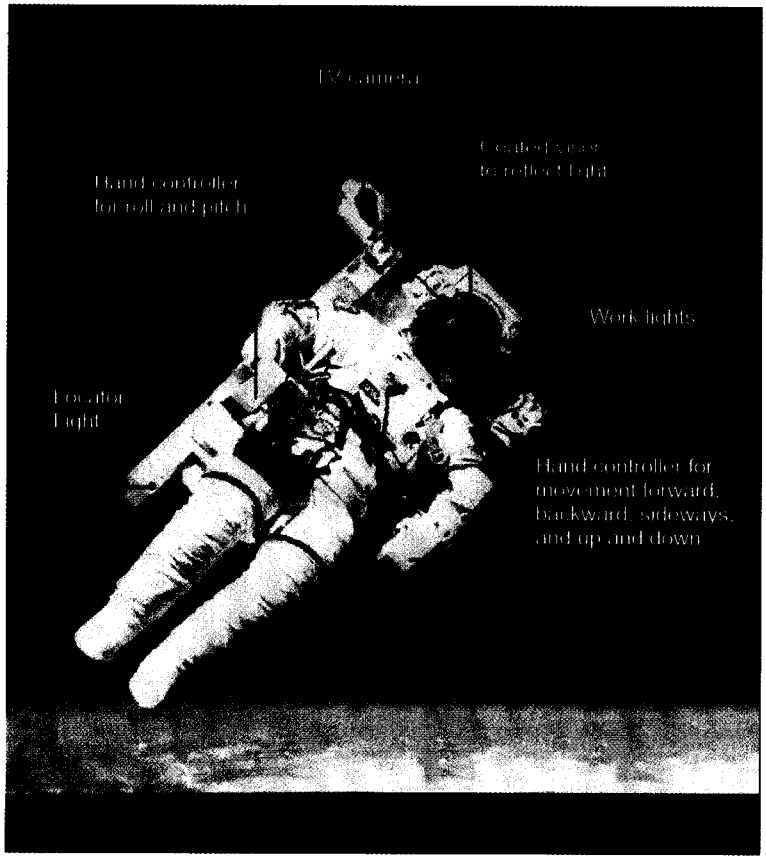
Pressure suits worn by the seven *Mercury* astronauts.

***Gemini* astronauts wore light weight space suits.**

***Apollo* astronauts wore a more advanced suit for moon walking.**

In 1984, the astronaut used the **Manned Maneuvering Unit (MMU)** for the first time. This unit fit on the astronaut's back and allowed him or her to move around without being tied to the spacecraft.

As you can see, space suits have come a long way. The improvements in the suits have allowed



The Manned Maneuvering Unit

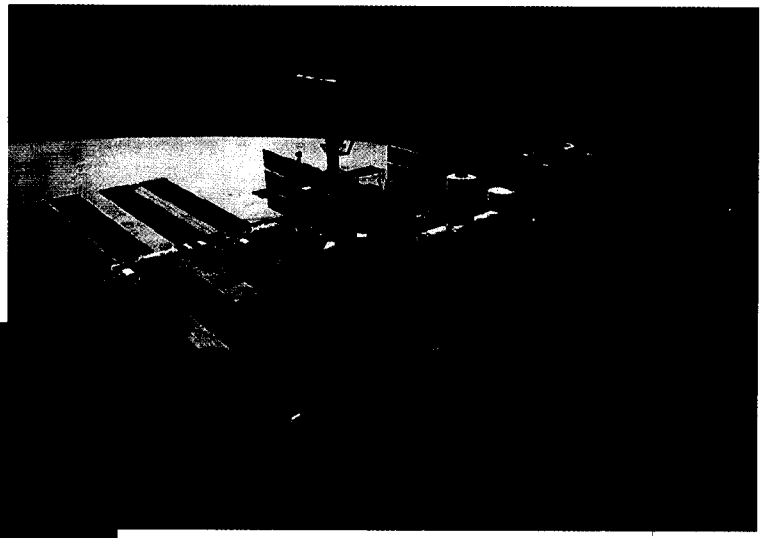
the astronauts to do much more in space, and do it more efficiently.

THE FUTURE IN SPACE

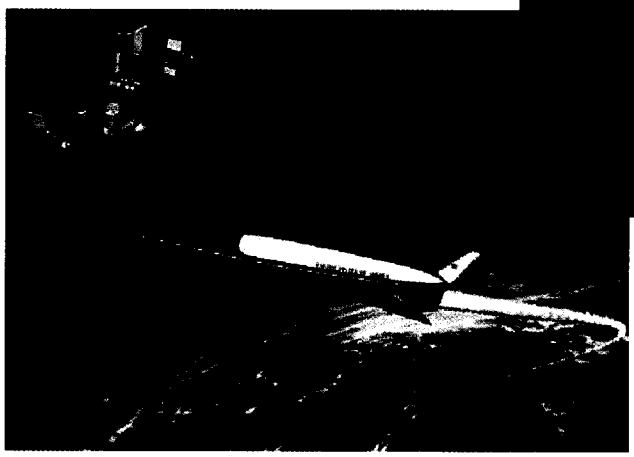
Due to our enduring fascination with space, indications are that space travel will continue into the unforeseeable future. We have come a long way since Russia launched *Sputnik* in 1957, and with each additional mission, we seem to learn more and more. In many people's minds, this increased knowledge justifies a persistent, progressive space program.

In November 1998, the first of several launches that will construct ***Space Station Alpha*** began. It will take about 15 shuttle flights to complete *Alpha.* *Alpha* is a joint venture with US, Europe, Canada, Japan and Russia. It is to be the permanent space station of the very near future. If the shuttle flights launch on schedule, the space station should be completed in 2004. Each of the members of the venture is responsible for various parts of the project. So, every country must accomplish its tasks in order for *Alpha* to be built on time.

Space travel could take on a new look in the future. The shuttle has done a superb job of taking astronauts

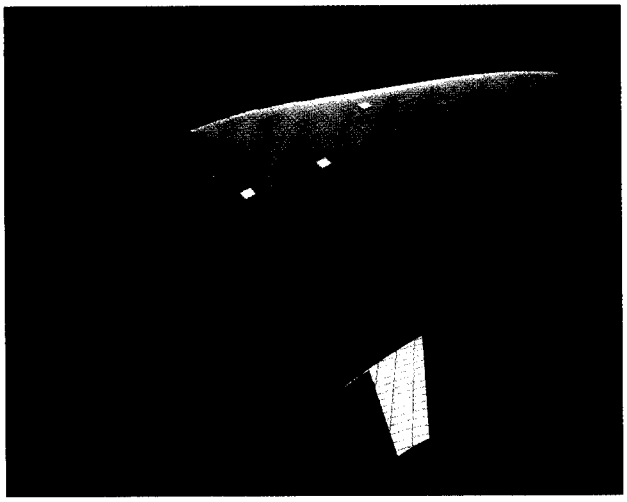


The *International Space Station*



→ **Future Transatmospheric Aircraft**

into space and bringing them back. However, improvements can be made. NASA has been researching replacements for the *Space Shuttle* and decided that the *X*-33 will replace the Space Shuttle in the 21st century. The *X*-33 is a single-stage-to-orbit reusable launch vehicle that lifts off into space and returns to Earth intact.



The *X*-33 Reusable Launch Vehicle. ⟶

The experimental *Delta Clipper* takes off and lands vertically and will be a breakthrough in low earth orbit travel.

See Activity One - Investigating Weightlessness
Refer to the activity Section at the end of the chapter for this Activity. ⟶

See Activity Two - Keeping Cool
Refer to the activity Section at the end of the chapter for this Activity. ⟶

See Activity Three - How Does Motion Cause Disorientation?
Refer to the activity Section at the end of the chapter for this Activity. ⟶

THINGS TO REMEMBER

It looks like space travel is here to stay, and the missions may get more and more plentiful. We may see the day when many average folks travel to the Moon and beyond.

Space stations are certainly helping ease some of the burdens of space travel. Astronauts can stop by a space station and rest for a while, and then either work or go on to another destination. Living in space for extended periods of time is becoming easier. Don't forget to look at the activities section.

REVIEW QUESTIONS

1. The United States' first space station was called
   a. *Mir.*
   b. *Space Station Alpha.*
   c. *Skylab.*
   d. *Spacelab.*

2. Russia's second generation space station is called
   a. *Space Station Alpha.*
   b. *Skylab.*
   c. *Spacelab.*
   d. *Mir.*

3. Research has shown that living in space for extended periods of time is not possible.
   a. True
   b. False